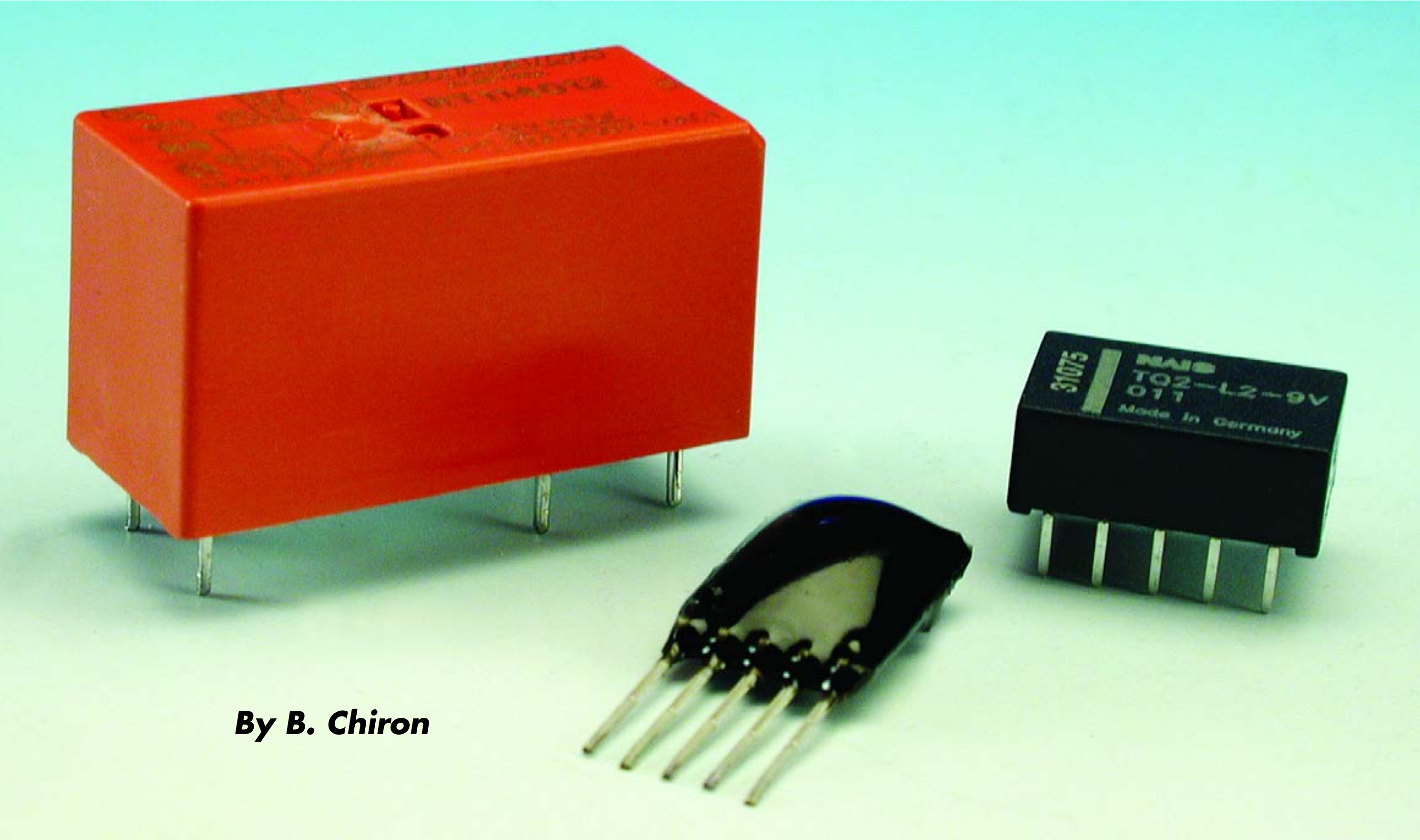
BISTABLE RELAY



By B. Chiron

Although bistable relays boast significant advantages, their use appears limited to niche applications, probably because their practical use requires just a tad more attention to design details than classic relays. Those days may be over soon with the introduction of a special driver IC from Quasinil (what's in a name?).

It appears that most manufacturers of bistable relays have now succeeded in simplifying their products to the extent that a demagnetising circuit is no longer required, and a single switching signal does the job. In some cases it is possible to realise a driver circuit based on just a few discrete components. In this article we show the intricacies of bistable relay control, analyse a few simple circuits, mention the pros and cons and, finally, introduce the dedicated drivers type DRT5 and DRL5.

Pros and cons of bistable relays

Advantages

The main advantage of a bistable relay is evident from its name: as soon as the relay has switched, it remains in that position without consuming energy. This unique characteristic has quite a few consequences: no current consumption means less heat production, hence smaller heatsinks while the (rechargeable) battery sees its load current much reduced. In some cases, the use of a bistable relay allows a circuit to be simplified.

Disadvantages

- In general, the drive circuit is a little more complex than with a classic relay. Depending on the type of bistable relay, we need to either reverse the current flow or drive just one of the two coils. If we are looking at demagnetisation circuits, then it is also necessary to limit the current in compliance with the manufacturer's specifications.

DRIVER

- To be able to benefit from the bistable character of the relay the driver needs to have a timing element in the form of an RC network or an IC with a few passive components around it.
- If we're after energy reduction only, then the bistable character can work against us. To enable the relay to toggle when the supply voltage drops, a small amount of energy needs to be stored for use by the relay circuit watching the supply level.

Classes of bistable relay

Bistable relay with two coils

This is the most commonly found type. Each coil is responsible for a certain state of the relay. Some manufacturers indicate that series connection of the two coils allows the relay to be controlled as if it had just one coil.

Bistable relay with one coil

Less frequently seen, but very interesting if you are after significant energy reductions in your circuit. The entire coil is used to energize the contacts, as opposed to just half the coil length in the case of a 2-coil relay. With relays requiring a demagnetisation circuit, the demagnetisation has to be effected by means of a special resistor. In general, reversing the current in a coil is a bit more difficult. Further on in this article, a special circuit is shown for that purpose.

What to take into account

- To begin with, there's the minimum drive signal length, which should not be confused with the relay's energising time. We're looking at the time needed to make the relay change over to its new position and remain in that state. If this time is specified in the datasheets, it is usually called 'min. signal width' or 'pulse length'. Lacking this information we may use the 'set time' and 'reset time' specifications and add a safety margin.

- Minimum switching voltage: 'must operate voltage', thus is the lowest voltage at which the relay is guaranteed to toggle. It is essential to check whether the drive voltage reaches this level during the minimum pulse duration.

- Maximum switching voltage: just as with a classic relay, this voltage may not be exceeded.

–With regard to isolation and contact ratings, the same applies as with traditional relays. If a relay is used as an isolator for the sake of electrical safety in a circuit, then a lower coil resistance results in better isolation properties.

- Distance to other relays: some manufacturers specify a smallest distance to other relays in order to minimise mutual disturbances.

- Maximum energising time: some relays do not withstand continuous driving, having been optimised for the duration of the switching pulse only. With this type of relay, pay special attention to an accurately defined switching pulse.

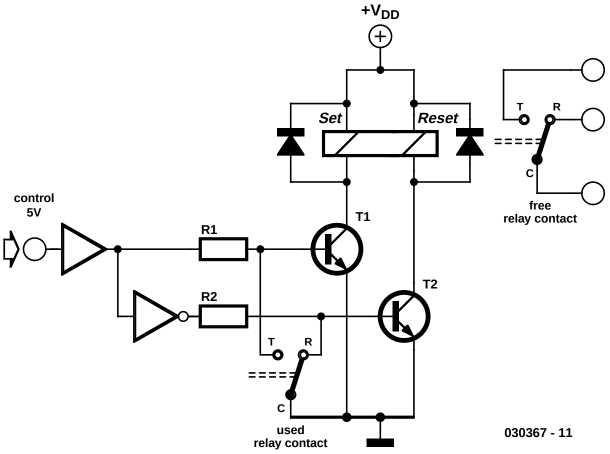


Figure 1. Relay control based on a classic contact-hold configuration.

Some really thrifty control circuits

Relay drive with hold by way of switching contacts (Figure 1)

Principle

When a logic High level is applied, T1 will conduct and current will flow through coil 'SET'. As soon as the relay pulls in, T1 blocks, cutting the relay coil current. When the control signal goes logic Low, the same happens with T2 and the 'RESET' coil.

Advantages

- Excellent for equipment that needs to be turned on, even in the case of a malfunction or a slowly rising supply voltage.
- Suitable for a 5-V suppy.
- No capacitor required.

Disadvantages

- One relay contact is sacrificed for the control method.
- Isolation sets higher demands to board layout.
- Depending on the relay type used, the relay switching time may be shorter than the prescribed minimum switching time, hence a risk of intermittent switching is created.
- The position of the contacts when powering off depends on the decay time of the supply voltage.

Adaptations

- Add energy buffer for switch-off phase.
- Add bridge rectifier for single-coil variant.
- Delay switching contacts to increase switching time.

Relay drive with a series capacitor (Figure 2)

Principle

At an input voltage of 12 V, C1 is charged, causing a brief current through the coil so the relay toggles. Next, the current remains limited to level determined by R1. If the input voltage drops abruptly to 0 V, the capacitor dis-

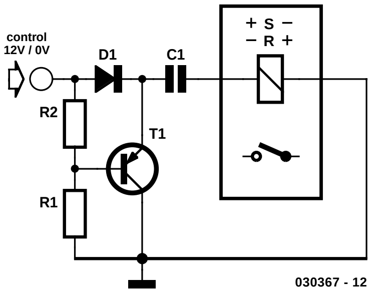


Figure 2. Relay drive using a capacitor.

charges via the relay coil with a reversed current, causing the relay to change to the reset state.

Advantage
- Simple structure for applications with clearly defined switching voltages.

Disadvantages
- Short pulses at the input may charge or discharge C1 without the relay switching (for example, while the supply is switched on or off).
- Functions badly at switching voltages of just 5 V.

Adaptations
- Schmitt trigger to be added when faced with slowly rising or dropping supply voltages.
- Modification possible for 2-coil relays.
- Possibility to add an energy-wise control input.

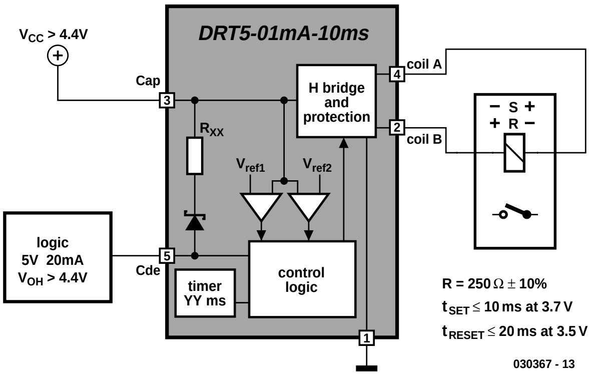


Figure 3. Switching with the aid of a logic signal and a DRT5.

The DRT5 driver

The Quasinil company offers a series of driver ICs specifically designed for driving bistable relays. The ICs are best described with the aid of a few examples. In the first of these, the basic operation is explained, while the second allows us to benefit from one of the most interesting and worthwhile characteristics: low-energy drive. A third example, finally, shows an example illustrating guaranteed switching levels.

Switching by logic level (Figure 3)

With V_{cc} = 5 V and C_{de} = 5 V the driver switches the relay to the ON position (10 ms pulse). When Cde returns to 0 V, the OFF state is switched on (20 ms pulse). Take into account that the driver will attempt to switch the relay to the OFF state when Vcc drops below about 3.7 V. The success of this operation is wholly dependent on Vcc.

Advantages
- Uncluttered, only one part needed.
- Suitable for 5-V powering.
- No capacitor required

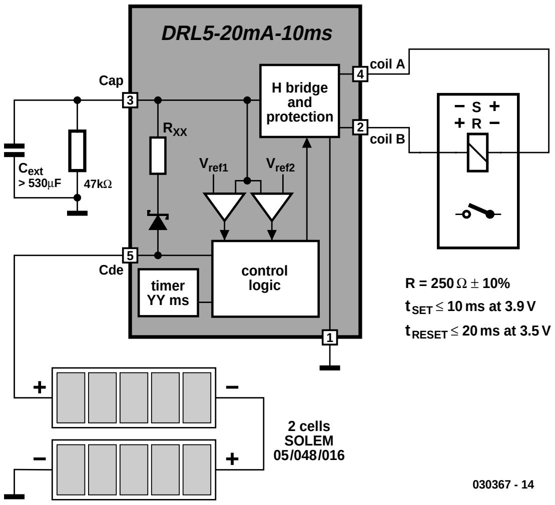


Figure 4. A simple dusk/dawn switch.

Disadvantages
- Slightly lags the control signal (approx. 20 ms).
- V_{cc} not allowed to exceed 5.5 V.
- If V_{cc} drops too quickly, the relay may not make it to the OFF state.

Adaptations
- Also works with 2-coil relays.
- For a simple method of supply voltage detection it is sufficient to connect Cap and Cde (although in that case the supply voltage has to drop very slowly).

Dusk/dawn switch (Figure 4)

Principle

Direct current furnished by solar cells charges capacitor C_{ext}. When the voltage across C_{ext} exceeds about 4.4 V, the relay will switch to ON. When the light intensity drops, the voltage across C_{ap} drops also. At a level of 3.7 V, the relay switches to OFF again.

Advantage
– No battery required.

Disadvantages
- Relatively long charge and discharge times (approx. 1 minute assuming two solar cells exposed to daylight).
- Large hysteresis: much more light is required to switch the relay to ON than to OFF

Adaptations
- For poor light conditions, use solar cells that supply a higher voltage. Protect the circuit with a low-drop voltage regulator (LP2950CZ-5).
- Although the configuration may also be used with a 2-coil relay, this option is less appealing because the capacitor becomes larger and with it the charge time.
- This type of circuit (typ. current consumption 20 mA) represents a cheap alternative to an optocoupler input. Depending on the source and the length of the cable it may be necessary to protect the driver's C_{de} input.
- Employ a power relay if larger currents are to be switched.

Controlling the mains supply in an USB device (Figure 5)

When the PC is switched on, capacitor C_{ext} is charged via a current limiting resistor. Once the capacitor voltage has risen to 4.4 V, the relay follows the state of the USB microcontroller, switching to ON. When the PC is switched off, the relay returns it its initial state. In this way, the supply in a peripheral device is switched synchronously with the PC.

Advantage
– OFF state guaranteed when PC is switched off.

Disadvantages
- Slightly lags the control signal (approx. 20 ms).
- Supply voltage not to exceed 5.5 V.
- Driver is relatively expensive.

Adaptations
- The relay in the example is a power relay, hence the value of the capacitor. Depending on the power to be switched and the desired degree of isolation, a small relay may be chosen. A single-coil relay allows a smaller capacitor to be used.
- If the peripheral is to receive its supply voltage together with the PC, the microcontroller is not required. Simply connect the 5 V of the USB connector to C_{de} and fit a 100-kΩ resistor between Cde and ground.

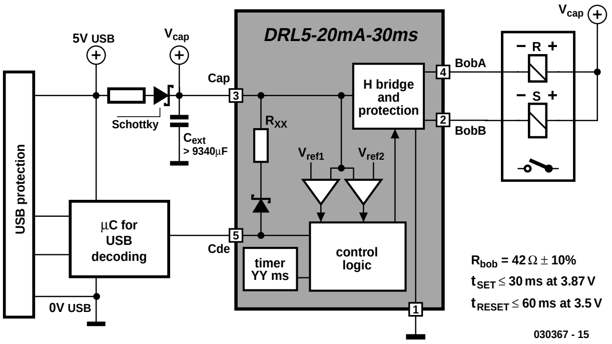


Figure 5. Switching a SB internal supply on and off.

Choice between DRT5 and DRL5

In the three above examples we discussed a few aspects of these new driver ICs. The choice of the type of driver is closely related to the application and the relay to be controlled. Below is a short discussion of the parameters for these drivers and some advice to choose the right type.

DRT or DRL: The DRL5 driver is suitable for use in equipment with a supply or control voltage greater than 4.75 V. By contrast, the DRT5 may be used at a lower supply level starting at 4.4 V. This difference in supply voltage is also relevant to applications using an external capacitor.

Maximum current of the control input: This parameter is especially important if the driver is used without a power supply. In that case, capacitor Cext needs to be charged from, say, a logic gate. Depending on the allowed or desired control current we choose the version with current limiting at 1 mA, 10 mA, 20 mA or 50 mA.

Control pulse length: This time has to exceed the 'minimum switching time' required by the relay. Possible times are 5, 10, 20, 30 or 50 ms. The OFF switching pulse is twice as long, which allows the value of the external capacitor to be optimised if necessary.

Really useful!

Compared with existing solutions, the DRT5/DRL5 drivers enable relays to be controlled with very low currents indeed, take the switching characteristics of the relay fully into account and guarantee the state of the relay when the equipment is switched off. Unfortunately the down side of the new drivers is their relatively high cost. Of course, we hope that the price will drop with volume production. In any case, these new devices offer the electronics designer extra options in circuits where energy consumption is a prime consideration, such as all newly designed equipment powered by batteries or solar cells.

More information on these components may be obtained from Quasinil's Internet site at
http://www.quasinil.com
and in particular this address
http://20gp.ovh.net/~quasinil/drivers_eng.htm

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